LOUISIANA COASTAL PROTECTION AND RESTORATION TECHNICAL REPORT

DRAFT

ECONOMICS APPENDIX

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INTRODUCTION AND BACKGROUND

The purpose of this appendix is to provide details on the economics analysis for the Louisiana Coastal Protection and Restoration (LACPR) technical evaluation, which presents “a full range of flood control, coastal restoration, and hurricane protection measures” as directed by Congress.

Congress also directed that the LACPR analysis to be conducted “exclusive of normal policy considerations.” Therefore, LACPR alternatives are being evaluated in a risk-informed decision framework across a wide range of metrics, rather than through the use of traditional methodology based on National Economic Development (NED) and/or environmental restoration benefits. This approach not only provides for the quantification of the damages reduced by the various alternatives plans, but it also allows for the quantification of other risk reduction parameters.

As a means to process data for approximately 60,000 census data blocks under multiple future scenarios, the LACPR team developed a customized geographic information system (GIS), which utilized remotely-sensed data to assess the damages to residential and nonresidential structures, their contents, and vehicles as well as agricultural resources, roads and railroads in the LACPR planning area. The application was also used to determine the number of structures, population, employment, income, and output affected by the stages associated with various frequency flood events. This inventory allows the LACPR team to evaluate alternatives and interact with stakeholders using a flexible and meaningful level of outputs.

Planning Units and Subunits

Located in South Louisiana, the LACPR planning area contains all or portions of the 26 parishes that could be affected by the storm surge from hurricanes and tropical storms. It extends from the Pearl River on the Louisiana/Mississippi border west to the Sabine River on the Louisiana/Texas border. The area was divided into five planning units, which are based on hydrologic basins and watersheds rather than on existing political and economic boundaries.

Planning Unit 1, the Lake Pontchartrain Basin, includes the city of New Orleans, the east bank of Jefferson Parish, and the north shore of Lake Pontchartrain and is the most densely populated planning unit in coastal Louisiana. It is bounded by the Mississippi River to the west, Interstate 12 to the north, the Pearl River to the east, and the Gulf of Mexico to the south.

Planning Unit 2, the Barataria Basin, is a highly productive estuary that contains the heavily populated west bank of Orleans and Jefferson Parishes. It is a triangular shaped area bounded by Bayou Lafourche, the Mississippi River, and the Gulf of Mexico.

Planning Unit 3a, the East Terrebonne Basin, contains the cities of Houma, Thibodaux, and Morgan City. It is bounded by Bayou Lafourche to the east, Interstate 10 to the north, and the Gulf of Mexico to the south. Its western border includes the East Atchafalaya Protection Levee to the GIWW in Morgan City, the GIWW to Miner's Canal, Miner's Canal to Lake de Cade, Lake de Cade to Lake Merchant, Lake Merchant to East Bay Junop, and East Bay Junop to the Gulf of Mexico.

Planning Unit 3b, the Atchafalaya Influence Area, contains the city of Lafayette and the communities of New Iberia, Berwick, Abbeville, and Erath. It is bounded by Planning Unit 3a to the east, Interstate 10 to the north, and the Gulf of Mexico to the south. Its western border extends south from the city of Lafayette to Freshwater Bayou Canal and follows Freshwater Bayou Canal to the Gulf of Mexico.

Planning Unit 4, the Chenier Plain, includes the city of Lake Charles and the communities of Sulphur, Crowley, Jennings, and Cameron. It is bounded by Planning Unit 3b to the east, Interstate 10 to the north, the Sabine River to the west, and the Gulf of Mexico.

The five planning units in the LACPR planning area were further delineated into planning subunits based on consistent topographical and hydrological characteristics. Planning Units 1 and 2 each contain approximately 100 planning subunits. Planning Units 3a, 3b, and 4 consist of approximately 700 subunits total. A map depicting the locations of the five planning units in the planning area is shown in the main report.

Previous Flood Events

While the planning area has periodically experienced localized flooding from excessive rainfall events, the primary cause of the flood events that have taken place in South Louisiana has been the tidal surges from hurricanes and tropical storms. During the past 30 years, the planning area has been affected by numerous hurricanes and tropical storms of various intensities. The tidal surges associated with these storm events have inundated structures and resulted in billions of dollars in damages to coastal Louisiana. A summary of these storm events, the years of occurrence, and the planning units that were impacted is provided below.

<u>Non-Tropical Events</u>. Numerous rainfall events have affected the Metropolitan New Orleans area and other portions of urban areas in Louisiana; however, the most severe of these events in terms of damage occurred in May of 1995. Rainfall amounts of up to 17.5 inched were reported within a 24-hour period in some areas of Jefferson and Orleans Parishes (Planning Units 1 and 2). Approximately 43,000 residential structures incurred damage in the metropolitan area, with insurance flood claims totaling nearly $600 million dollars. Spring floods and rainfall caused backwater flooding in the city of Morgan City

(Planning Unit 3b) in 1973, city of Baton Rouge (Planning Unit 1) in 1982, and the cities of Houma and Thibodaux (Planning Unit 3a) in 1991.

Hurricane Juan. Hurricane Juan caused extensive flooding throughout southern Louisiana due to its prolonged 5-day movement back and forth along the Louisiana coast in October 1985. The majority of the flood damage occurred in the Lincolnshire and Westminster subdivisions located on the west bank of Jefferson Parish (Planning Unit 2). Rainfall totals in the area ranged from five inches to almost 17 inches. The storm was responsible for storm surges of five to eight feet and tides of three to six above normal. According to FEMA officials, the estimated value of the residential and commercial damage and public assistance totaled $112.5 million.

Planning Unit 3a also incurred extensive damage as a result of Hurricane Juan. Over 800 homes were inundated in the coastal portion of Terrebonne Parish south of the city of Houma. Scattered pockets of flooding were also reported in the portions of Terrebonne and Lafourche Parishes north of Houma. Approximately 40 percent of the homes in the coastal areas of Lafourche Parish, including Pointe-aux-Chenes, were also inundated by the high tides.

Agricultural damages from the storm totaled $175 million, with 24 percent of these damages occurring in Lafourche and Terrebonne Parishes. The soybean crop suffered over half of the agricultural damage, while the sugar cane crop incurred 20 percent of the damage. Excessive rains oversaturated the fields and caused a reduction in crop yields. The saturated fields also made it easier for the winds to topple over the cane stalks.

Hurricane Andrew. Shortly after midnight on August 26, 1992, Hurricane Andrew made landfall in St. Mary Parish, 80 miles west of Morgan City. Following its landfall, the storm changed its course from northwest to north and battered the Acadiana Parishes of St. Mary, Iberia, and Lafayette (Planning Unit 3b) as well as Lafourche and Terrebonne Parishes (Planning Unit 3a). The rapid speed of the storm and the direction of its movement into Louisiana greatly reduced its storm surge and limited its flood damage potential. Because the storm skirted the coast before moving inland, its winds pushed the stages downward. These lowered stages were able to absorb much of the tidal surge when the eye moved ashore and the winds changed directions. As a result, tidal flooding in coastal parishes was minimized.

FEMA reported that over 2,000 flood claims were filed as a result of this storm in Louisiana. These claims had a total value of over $25 million. Over 90 percent of this flood damage occurred in the Terrebonne Parish communities south of Houma, where up to six feet of water was reported. Only minor flooding in the back parts of subdivisions was reported in the city of Houma and in the areas north of the city. The unleveed portion of Lafourche Parish along its border with Terrebonne Parish, which includes the community of Pointe-au-Chien, also incurred extensive flood damage. The majority of the agricultural damage in the area occurred as the result of wind damage to the sugar cane crop.

Tropical Storm Isidore and Hurricane Lili. Tropical Storm Isidore and Hurricane Lili caused widespread damage in the central and eastern coastal areas of the state during the fall of 2002. Tropical Storm Isidore made landfall west of the mouth of the Mississippi River near Grand Isle and Port Fourchon on the morning of September 26, 2002. After the storm moved inland, it took a northeasterly path across eastern New Orleans and Slidell. The approaching storm pushed high tides toward the southern shore of Lake Pontchartrain. This caused flooding in the portion of St. Charles Parish outside of the Federal levee protection (Planning Unit 1). However, as the center of the storm moved north of the lake, the winds shifted direction and pushed the high tides inland along the lakefront of St. Tammany Parish. This caused extensive flooding in the lakefront subdivisions of Mandeville and Slidell (Planning Unit 1).

One week later on October 3, 2002, Hurricane Lili made landfall on the western edge of Vermilion Bay south of the cities of Abbeville and New Iberia (Planning Unit 3b) as a weak Category 2 hurricane. Winds toppled trees and power lines leaving approximately half a million people without electricity immediately after the storm. The high winds caused tidal flooding in the communities east of the eye of the storm. The ridge communities in Terrebonne Parish south of the city of Houma, including Cocodrie, Dulac, Isle de Jean Charles, and Montegut, and the community of Pointe-aux-Chenes in Lafourche Parish were affected by tidal flooding (Planning Unit 3a). The only community south of Houma that did not flood was Chauvin. As the storm moved north, tidal flooding similar to that from Tropical Storm Isidore inundated the lakefront subdivisions of Mandeville and Slidell in St. Tammany Parish, the coastal communities of Lafitte and Grand Isle in Jefferson Parish, and the coastal portions of Plaquemines and St. Bernard Parishes (Planning Unit 1). Each of these areas is outside the existing Federal levee systems.

Insured losses from Tropical Storm Isidore and Hurricane Lili totaled nearly $600 million. New Orleans District has estimated that flooding caused approximately 80 percent of these damages, while the remainder was caused by wind and flying debris. Approximately $105 million of insured losses were related to Tropical Storm Isidore, while Hurricane Lili caused $471 million of insured losses. According to windshield surveys conducted by the American Red Cross, approximately 10,000 residential structures were damaged by the two storms. These surveys included both insured and uninsured structures. Tropical Storm Isidore caused damage to 2,905 structures, while Hurricane Lili caused damage to 7,356 structures.

In a revised report released in mid-November by the Louisiana State University Agricultural Center (LSU AgCenter), the estimated agricultural damages caused by Tropical Storm Isidore and Hurricane Lili totaled $454.3 million. This estimate also includes the agricultural damages caused by the continuation of rain during the month of October, which delayed the harvesting of crops. The excessive rains flooded the agricultural fields and increased the harvest costs.

The wind and waves of Tropical Storm Isidore and Hurricane Lili caused extensive beach erosion in the barrier islands of Louisiana. These islands protect the coastline of the state and provide a natural habitat for many species of wildlife. The barrier islands west of the mouth of the Mississippi River that were affected by the two storm events include the Isles Dernieres (Whiskey Bayou, Raccoon Island, Trinity Island, and East Island), Timbalier Island, East Timbalier Island, Elmer Island, and Grand Terre. Grand Isle incurred extensive damage along its eastern beach. Three small islands east of the mouth of the Mississippi River, Grand Gosier Island, Curlew Island, and Chandeleur Island, incurred extensive damage and beach erosion. A monetary value has not been determined for these environmental damages.

Hurricane Katrina. The most significant storm event to affect the Metropolitan New Orleans Area (Planning Unit 1) since Hurricane Betsy in 1965 was Hurricane Katrina. Hurricane Katrina made landfall on August 29, 2005, near the town of Buras in Plaquemines Parish as a Category 3 storm with winds in excess of 120 miles per hour. However, its storm surge of approximately 30 feet was more characteristic of a Category 5 hurricane. After tracking across the southeastern Louisiana coastline, it made a second landfall near the town of Waveland on the Mississippi Gulf Coast. The surge from Lake Pontchartrain pushed water into the three major outflow canals (London Avenue, Orleans, and 17th Street) of the city of New Orleans, which overwhelmed their adjacent floodwalls. The surge from Lake Borgne overwhelmed the levees protecting St. Bernard Parish, New Orleans East, and the Lower Ninth Ward. Many portions of the metropolitan area were submerged in more than 6 feet of water for more than 3 weeks. Area pump stations were left inoperable or inaccessible, which caused the dewatering process to take approximately 53 days.

According to the Department of Health and Hospitals (DHH), approximately 1,400 deaths were reported following Hurricane Katrina. Approximately 1.3 million residents were displaced immediately following the storm, and 900,000 residents remained displaced as of October 5, 2005. According to the Louisiana Recovery Authority (LRA), two years after the storm, approximately 210,000 FEMA applicants still have out-of state mailing addresses, while 230,000 FEMA applicants have an in-state mailing address in a different zip code.

The storm caused more than $40.6 billion of insured losses to the homes, businesses, and vehicles in six states. Approximately two thirds of these losses, or $25.3 billion, occurred in Louisiana based on data obtained from the Insurance Information Institute. According to the LRA, approximately 150,000 housing units were damaged, and according to the Department of Environmental Quality (DEQ), 350,000 vehicles, and 60,000 fishing and recreational vessels were damaged.

As of January 2007, approximately $30 billion in Federal funds have been obligated to Louisiana residents through Individual and Public Assistance Programs, National Flood Insurance claims, and Small Business Administration (SBA) disaster loan. Individual assistance grants, which totaled approximately $5.7 billion, included $3.8 billion for Housing Assistance (temporary housing, repair and replacement, and permanent housing construction), $1.6 billion for Other Needs Assistance (personal property, transportation, medical and dental expenses, and moving and storage cost), and $320 million for Disaster Unemployment Assistance. Public Assistance Grants, which totaled approximately $4.5 billion and are projected to reach $6.3 billion, included assistance to state and local governments to rebuild publicly owned infrastructure, such as schools, government offices, parks, and sewer lines. The National Flood Insurance Program has paid approximately $12.9 billion in Federal flood insurance claims to residents in the State of Louisiana. In addition, the SBA has approved approximately $6.8 billion in low-interest loans for homeowners, renters and businesses.

The storm surge from Hurricane Katrina inundated marshes and farmland throughout the coastal area. According to the LSU AgCenter, agricultural losses totaled approximately $825 million. The agricultural resources impacted by the storm include sugarcane, cotton, rice, soybeans, timber, pecans, citrus, and livestock. The losses to aquaculture (crawfish, alligators, and turtles), fisheries (shrimp, oysters, and menhaden), and wildlife and recreational resources totaled approximately $175 million.

Hurricane Rita. The most significant flood event to affect the southwest portion of the planning area (Planning Unit 4) since Hurricane Audrey in 1957 was Hurricane Rita. Hurricane Rita made landfall along the Texas-Louisiana border on September 24, 2005, as a Category 3 storm with winds in excess of 120 miles per hour. A storm surge of approximately 15 - 20 feet affected the coastal region from Port Arthur, Texas to Terrebonne Parish, Louisiana. The flooding extended north to Lake Charles, where the downtown and residential areas around the lake were covered with 3 – 6 feet of flooding. With estimated insured losses of approximately $5 billion, Hurricane Rita became one of the most costly natural disasters in U.S. history. Approximately 55,000 housing units in Calcasieu, Cameron, and Vermilion parishes incurred flood damages as a result of this hurricane.

Approximately 2,000 square miles of farmland and marshes throughout the coastal area were inundated. According to the LSU AgCenter, agricultural losses totaled approximately $490 million. The agricultural resources impacted by the storm include sugarcane, cotton, rice, soybeans, timber, pecans, citrus, and livestock. The losses to aquaculture (crawfish, alligators, and turtles), fisheries (shrimp, oysters, and menhaden), and wildlife and recreational resources totaled approximately $100 million.

STRUCTURE INVENTORY METHODOLOGY

GIS Application

A customized GIS framework, or application, similar to the one used by the Interagency Performance Evaluation Task Force (IPET) for the Hurricane Katrina IPET Report was used to assess the damages to residential and non-residential structures, their contents, and vehicles in the LACPR planning area. The application was used to develop a water elevation-damage, or stage-damage, relationship for each census block in the LACPR planning area. Inputs to the application included elevation data, depreciated exposure values of residential and nonresidential structures, and depth-damage relationships.

Ground Elevations

Topographical data obtained from the LIDAR (Light Detection and Ranging) digital elevation model (DEM) using the NAVD88 (2004.65 epoch), which were used for the IPET study area, were combined with census block boundaries obtained from the 2000 Census using GIS mapping to determine the mean ground elevation for each census block in the New Orleans metropolitan area. For the portion of the LACPR planning area outside of the New Orleans metropolitan area, unadjusted NAVD88 data were used to determine the mean ground elevation for each census block.

Two sources of uncertainty associated with the topographical data assigned to the structure inventory and agricultural resources were quantified: the uncertainty implicit within the LIDAR data and the uncertainty from using a single value to represent the elevation of an entire census block. According to the IPET report, the LIDAR topographical data is accurate to approximately plus or minus 1 foot at the 90 percent level of confidence. The error in each spot elevation based on the LIDAR data was assumed to be normally distributed with a mean of zero, a standard deviation of 0.61 feet, and a variance of 0.37 feet. In order to quantify the variability of the ground elevations within each census block, an average standard deviation was calculated across all census blocks in the LACPR planning area. The average standard deviation of the ground elevations within each census block was calculated to be 1.29 feet with a variance of 1.66 feet. Thus, the sum of the variances in the LIDAR data and in the ground elevation across all census blocks can be represented by a normal distribution with a variance of 2.03 feet and a standard deviation of 1.43 feet.

First Floor Elevations

An average height above ground was assigned to the residential structures in Jefferson and Orleans parishes based on data obtained from a first-floor elevation survey conducted by USACE personnel in 1991 by geographic areas known as traffic-zones. A sampling of residential structures in each traffic zone was used to estimate the percentage of residential structures with pier foundations and the percentage with slab foundations and to determine the average height of the pier and slab foundations above ground level. The surveys were also used to estimate the percentages of one-story and two-story residential structures in each traffic zone.

In St. Bernard, Plaquemines, and St. Charles parishes, the percentage of residential structures with pier and slab foundations, and the average pier and slab foundation heights were estimated for each community within these parishes based on the field surveys from previous feasibility studies in the area. Estimates were also made of the percentages of one-story and two-story residences in each community.

For each of the other parishes in the LACPR planning area, an average height above ground was assigned to the residential structures in each census block based on interviews with parish emergency management personnel. These officials were asked to estimate the percentage of residential structures with pier foundations and with slab foundations and to estimate the average height above ground level for each type of foundation. Mobile homes were assigned an average foundation height of 2.0 feet above ground level based on previous studies. For non-residential structures, an average height of 1.5 feet above ground was assigned to all non-residential properties in the planning area based on the information obtained during the interviews with parish emergency management personnel.

Residential Structure Inventory and Valuation

The LACPR planning area includes all or portions of 26 of the 64 civil parishes in the state, approximately 60,000 census blocks, and over one million residential and non-residential structures. Due to the large number of structures, as well as time constraints for completing the analysis, it was not feasible to inventory all of the structures in the planning area. The general building stock portion of the Hazard-U.S.-Multihazard (HAZUS-MH) application, MR2 Release 44 (copyright 2006, FEMA), a GIS-based multi-hazard loss estimation tool developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS) was used as a proxy for the structure inventory. This database was also used to estimate damages in the Interagency Performance Evaluation Team (IPET) Report.

The building stock data, which were based on data from the 2000 Census, were updated to represent 2nd quarter 2005 (Pre-Katrina) based on census block group data obtained from Calthorpe Associates, an urban planning agency contracted by the state of Louisiana as part of the Louisiana Speaks forum. The demographic trends identified in each parish were used to adjust the number of households, the number of residential structures, and the depreciated exposure values for each census block group in the HAZUS database. As an example, a shift in the pre-Katrina population of the New Orleans MSA was noted between the year 2000 and the 2nd quarter of 2005. During this period, the population of Orleans Parish decreased by approximately 30,000 people, while the population of St. Tammany Parish increased by an almost identical amount.

The updated HAZUS-MH database was used in the GIS application to provide the total square footage, building count, and the total depreciated exposure value for residential occupancies by census block. HAZUS-MH combined data from the 2000 Census with data from the Department of Energy Building Characteristic Reports to assign a total square footage to each of six residential occupancy categories: single-family dwellings, manufactured housing/mobile homes, multi-family dwellings, temporary lodgings, institutional dormitories, and nursing homes. It then combined the square footage for each residential occupancy category with the average age of the buildings in the area and a corresponding depreciation schedule to derive the depreciated exposure value for that category. These values, which were expressed in 2005 price levels and updated to 2006 price levels using the Marshall and Swift Valuation Service, were entered into the GIS framework by census block.

The depreciated exposure values were also adjusted to reflect the underestimation of the HAZUS-MH data as noted in the Interagency Performance Evaluation Team (IPET) Report in 2006. In this report, the total depreciated exposure value for each census block was compared to the depreciated replacement cost for residential structures that was calculated by USACE personnel using field surveys and the Marshall and Swift Valuation Service. A sampling of 40 city blocks from structure inventories compiled as part of feasibility studies conducted since the year 2000 in the New Orleans Metropolitan Area was used in the comparison. The sampled depreciated replacements costs were found to be approximately 16 percent higher than the depreciated exposure values calculated by HAZUS-MH. To account for this underestimation, the depreciated exposure values calculated within HAZUS-MH were increased by 16 percent.

The GIS application was used to allocate the depreciated exposure values that had been calculated for the residential occupancy category “single-family dwellings” within each census block into one-story and two-story structures and into pier and slab foundations. An estimate of the percentage of one and two-story residential structures in each parish within the planning area was provided by emergency management officials. This step was necessary in order to apply the depth-damage relationships to the different types of single-family dwellings.

Temporary lodgings, institutional dormitories, and nursing homes, which are normally valued as non-residential structures in USACE studies, were processed as residential structures in the GIS application. Each of these buildings was assigned to the public damage category and the public occupancy classification to calculate the damages. The average depreciated replacement cost calculated for the public occupancy classification was used for these buildings. The damages for these buildings are displayed in the GIS application as part of the multi-family damage category.

Non-Residential Structure Inventory and Valuation

The non-residential structure inventory was compiled using databases obtained from the Louisiana Department of Labor (LDOL) and the Louisiana State University GIS Department. The LDOL database provided a geo-referenced latitude/longitude coordinate for each business property in the planning area that had been registered for unemployment insurance. The latitude/longitude coordinates were used in the GIS application to relate the location of each business property to a census block in the planning area. The LDOL database provided a North American Industry Classification

System (NAICS) code, which describes the type of business occupancy at each location, along with the number of employees, and total wages paid for second quarter 2005 (pre-Katrina conditions) for each business unit. Since many small businesses operate out of residential structures, and these structures were included in the residential inventory, only the businesses that employed more than one person were included in this analysis.

The NAICS codes were grouped into four general damage categories (commercial, industrial, agricultural, and public), and then assigned to one of eight non-residential occupancy classifications. The eight non-residential occupancy classifications include: eating and recreation, groceries and gas stations, professional buildings, public and semi-public facilities, repairs and home use, retail and personal services, warehouse and contractor services, and industrial facilities. An average depreciated replacement cost using 2006 price levels was calculated for each occupancy classification, except for industrial facilities, based on previous feasibility studies conducted by New Orleans District using the Marshall and Swift Valuation Service. Since the previous feasibility studies did not include a significant number of industrial properties, the Dun and Bradstreet database within the HAZUS-MH application was used to determine the average depreciated replacement cost of industrial buildings.

The LDOL database provided only a single latitude/longitude coordinate for the central reporting office of the schools, post offices, and churches. In order to have a separate location and value for each individual school, church, and post office in the planning area, a separate database was obtained from Louisiana State University. The community layer within the LSU GEOLAGIS database provided a geo-referenced latitude/longitude coordinate for each school, church, and post office in the planning area and a description of the facility. Each of these buildings was assigned to the public damage category and the public occupancy classification to calculate the damages. The average depreciated replacement cost calculated for the public occupancy classification was used for these buildings.

The following values in **Table 1** were assigned to each of the non-residential occupancy categories in the GIS application:

Table 1. Average Building Value by Non-residential Occupancy Category.

Non-residential Occupancy Category	Average Building Value
Eating & Recreation	$ 166,644
Groceries and Gas Stations	$ 151,613
Professional Buildings	$ 503,583
Public and Semi-Public	$ 699,987
Repair and Home Use	$ 111,812
Retail and Personal Services	$ 263,369
Warehouses and Contractor Services	$ 241,252
Industrial Buildings	$2,728,950

Residential and Non-Residential Contents Valuation

The contents for residential (one-story, two-story, mobile homes, and multi-family) and non-residential (eight categories) structures were determined based on limited field surveys and the experience of a building and insurance expert panel for the Jefferson and Orleans Parishes Feasibility Study in 1996; the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies in 1997; and the Donaldsonville to the Gulf, Louisiana Feasibility Study in 2006. The value of the contents of each structure category were totaled and then compared to the total value of a structure in order to develop the contents-to-structure ratios (CSVRs). More specific detail regarding the development of the content values can be found in the following final reports: *Depth-Damage Relationships for Structures, Contents, and Vehicles and Contents-to Structure-Value Ratios (CSVRs) in support of the Jefferson and Orleans Flood Control Feasibility Studies* dated May 1997, *Depth-Damage Relationships for Structures, Contents, and Vehicles and Contents-to Structure-Value Ratios (CSVRs) in support of the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies* dated May 1997, and *Donaldsonville to the Gulf, Louisiana Feasibility Study* dated March 2006.

The CSVRs and depth-damage relationships developed for the Jefferson and Orleans Studies were applied to residential and non-residential structures located in the eastern portion of the LACPR planning area that is west of the Louisiana/Mississippi state border and east of the Mississippi River. They were also applied to the west bank of the Mississippi River in Orleans and Jefferson parishes. The depth-damage relationships and CSVRs developed for the Donaldsonville area were applied to the areas east of Bayou Lafourche with the Mississippi River on the north, and the Jefferson Parish line on the east. The depth-damage relationships and CSVRs developed for the Lower Atchafalaya and Morganza to the Gulf study area were applied to the portion of the LACPR planning area that is west of the Mississippi River and west of Bayou Lafourche and extends to the Louisiana and Texas border. In summary, Planning Unit 1 utilized the Jefferson and Orleans CSVRs and depth-damage relationships, Planning Unit 2 was analyzed with Jefferson and Orleans CSVRs and depth-damage relationships for part of the area and with the Donaldsonville relationships for the remainder of the area, and Planning Units 3a, 3b, and 4 were covered by the Morganza CSVRs and depth-damage relationships.

The CSVRs developed for each of the four residential structure categories and eight non-residential occupancy classifications for the three feasibility studies are shown in **Table 2** below:

Table 2. Contents-to-Structure Value Ratios for Three Feasibility Studies.

Structure Category		Feasibility Study: Jefferson and Orleans Area	Feasibility Study: Donaldsonville to the Gulf Area	Feasibility Study: Lower Atchafalaya and Morganza to the Gulf Area
Residential	One-story	69%	69%	71%
	Two-story	59%	67%	50%
	Mobile home	79%	112%	148%
	Multi-family residence	37%	27%	23%
Non-residential	Eating and Recreation	114%	83%	306%
	Grocery and Gas Station	127%	397%	128%
	Professional building	43%	44%	78%
	Public and Semi-public Building	114%	79%	82%
	Repairs and Home Use	206%	74%	251%
	Retail and Personal Services	142%	367%	148%
	Warehouse and Contractor Services	168%	256%	372%
	Industrial	168%	256%	372%

The GIS application used the CSVRs as a percentage of the total depreciated exposure value or total depreciated replacement cost to determine the total value of the contents for each residential and non-residential occupancy classification. The CSVR calculated for warehouses and contractor services was also assigned to the industrial non-residential occupancy classification.

Vehicles

Damages to private automobiles are based on the number of automobiles directly impacted per household. The elevation of each automobile is determined by the corresponding ground elevation near the structure. Automobile damages are then calculated by correlating the depth of flooding to the depth-damage relationships for vehicles.

Census data were used to determine the average number of privately owned vehicles per household (owner occupied housing or rental unit) within each census block group in the planning area. This relationship was used in the GIS application to determine the average number of vehicles per household within each census block. Approximately 1.4 million privately owned vehicles and 135,000 vehicles associated with businesses were estimated for the 24 parishes subject to surges from hurricanes in the LACPR planning area. Based on the Southeast Louisiana and Mississippi Clearance Time Updates for the 2006 Hurricane Season Final Report prepared by Federal Emergency Management Agency and U.S. Army Corps of Engineers, New Orleans District dated June 1, 2006, and the Southwest Louisiana Hurricane Evacuation Report prepared by Federal Emergency Management Agency and U.S. Army Corps of Engineers, New Orleans District dated 2003, between 65 and 80 percent of the privately owned vehicles in Southeast Louisiana were used for evacuation from Hurricane Katrina. For this analysis, it was assumed that the average household would use 70 percent of its vehicles to evacuate during a storm event, while the remaining 30 percent of its vehicles would remain parked at the residence.

Residential automobile damages were based on the number of privately owned vehicles not used for evacuation. Each of these vehicles was assigned an average value of $12,217 as reported by the Manheim Used Vehicle Value Index, which is based on over 4 million automobile transactions conducted each year that has been adjusted to reflect the retail replacement value. The depth-damage relationships for vehicles that were developed based on interviews with the owners of automobile dealerships that had experienced flood damage. These interviews were conducted as part of the depth-damage reports and were used to calculate flood damages to vehicles at the various levels of flooding. It was assumed that each automobile was parked one foot below the elevation of slab houses and parked at the ground elevation of houses built on piers.

Commercial vehicle damages were based on the number of commercial licenses as reported by the Louisiana Department of Motor Vehicles for parishes in the planning area for October 2006 and the total number of business units for each parish. Based on these data, it was determined that there was an average of 2.7 vehicles associated with each business unit in the planning area. It was assumed that since the business owners were using their privately owned vehicle for evacuation, all commercial vehicles would remain parked at the business. The ground elevation assigned to these vehicles was the same as the ground elevation assigned to the business property. The Manheim average value, $12,217, and the vehicle depth-damage relationships were used to derive the potential damages to commercial vehicles.

Depth-Damage Relationships

Damages from flooding were calculated for residential and non-residential buildings, their contents, and vehicles based on the depth-damage relationships developed by a panel of building and construction experts for the Jefferson and Orleans Parishes Feasibility Study in 1996; the Lower Atchafalaya Reevaluation and Morganza to the Gulf, Louisiana Feasibility Studies in 1997; and the Donaldsonville to the Gulf, Louisiana Feasibility Study in 2006. Saltwater, long-duration (one-week) depth damage curves were used to indicate the percentage of the structural value that was damaged at each depth of flooding. Damage percentages were determined for each one-half foot increment from one foot below first-floor elevation to two feet above first floor, and for each 1-foot increment from 2 feet to 15 feet above first-floor elevation.

Depth-damage relationships were developed for one-story and two-story residential structures, mobile homes, and non-residential structures, their contents and vehicles. The panel of experts developed depth-damage relationships for four residential structure categories (one-story, two-story, mobile homes, and multi-family dwellings) and for three commercial structure categories (masonry, wood or steel frame, and metal frame). Depth-damage relationships were also developed for the four residential content categories and for seven commercial content categories. The non-residential depth-damage relationships were assigned to the appropriate structure and content damage category based on the NCAIS code and occupancy classification.

Pre-Katrina (2nd Quarter 2005) Stage-Damage Relationships

Inputs to the GIS application have thus far included elevation data, structure inventory and valuation data, and depth-damage relationships. The application used these inputs to generate a water elevation or stage-damage relationship for each census block. Flood damages were calculated at one-foot increments from the beginning damage elevation to an elevation where damages for all the structural categories have reached a maximum. In order to insure that this maximum had been reached, the maximum height of a slab foundation or of a pier foundation in each census block was added to the maximum depth of flooding (15 feet) included in the depth-damage relationships. Damages were calculated for eight structural damage categories: single-family residential, multi-family residential, manufactured housing/mobile homes, commercial, industrial, public, agricultural, and vehicles.

The GIS application was used to develop a stage-damage relationship for each of the approximately 60,000 census blocks in the LACPR planning area. These stage-damage relationships reflect pre-Katrina conditions (2nd Quarter 2005) and were developed using 2006 price levels. These relationships were used as the basis for the development of stage-damage relationships for any future year through the year 2075. It should be noted that any residential and non-residential structures and their vehicles that incurred flood damages from Hurricanes Katrina and Rita would not be included in this analysis until the owners of these properties have reoccupied their properties.

FUTURE DEVELOPMENT AND LAND USE ALLOCATION SCENARIOS

Since uncertainty is implicit in all future projections, several future condition scenarios were considered in this analysis rather than only one “most-likely” scenario as in previous studies. These scenarios will provide the decision maker with a more comprehensive view of possible future conditions and their impact on potential flood damages. In this section of the analysis, three future development scenarios were used to project the growth in population, number of households, and non-agricultural employment that will take place in the LACPR planning area by the year 2050. Three future land use allocation scenarios, which show the placement of this growth within the planning area and the type of residential and non-residential construction, were considered for each of the three future development scenarios. Due to the uncertainty of the length of the project implementation period, the projections under each scenario were extended by New Orleans District to the year 2075.

Future Development Scenarios

Projections of population, number of households, and total non-agricultural employment for each of the five Metropolitan Statistical Areas (MSAs), New Orleans, Baton Rouge, Houma, Lafayette, and Lake Charles, and for each of the non-MSA parishes in southern Louisiana were provided by Calthorpe Associates under two future development scenarios: "high employment" and "business as usual". These projections were based on the results of a custom application of the U.S. Macro Model, a macro-economic model prepared by Moody's Economy.com, and acquired through the Brookings Institution. The Economy.com model used factors such as net migration of population, employment demand by sectors of the economy, distribution of personal income, and residential construction patterns to project population, number of households, and non-agricultural employment for the period 4th Quarter 2005 through 4th Quarter 2034. New Orleans District personnel developed a third set of projections, "modified high employment"," which was a more conservative adaptation of the "high employment" projections. Estimates of the population for each of the parishes in South Louisiana as of July 1, 2006 obtained from Louisiana Tech University were used by New Orleans District personnel as a reference point for all three sets of population projections.

The "high employment" future development scenario assumes that the state of Louisiana will implement policies that will be conducive to increased employment in non-traditional Louisiana growth industries such as technology and medical services. Calthorpe Associates developed this scenario using the projections of the population, number of households, and total non-agricultural employment prepared by Economy.com for the period 4^{th} Quarter 2005 through 2030 for five MSAs and for the rural parishes in South Louisiana. Calthorpe Associates then used the projected growth rate during this 25-year period to extend the projections to the year 2050. In the areas affected by Hurricanes Katrina and Rita, the 4^{th} Quarter 2005 population was drastically reduced from its pre-Katrina level because a large portion of the population had evacuated from the impacted areas. Thus, the growth rate projected to occur between 4^{th} Quarter 2005 and the year 2010 as the population returns to the area is relatively higher than the growth rate projected to occur between the year 2010 and 2030 when most of the evacuated residents have returned. Since Calthorpe Associates used the growth rate for the 25-year period beginning 4^{th} quarter 2005 and extending through the year 2030, which includes the relatively high rate of growth expected during the five years following the two storms, to extend the Economy.com population projections through the year 2050, the projected growth rate in population accelerates during the 20-year period 2030 to 2050 relative to the projected growth rate during the 20-year period 2010 to 2030.

The “business as usual” future development scenario assumes that the state of Louisiana will continue to implement the economic policies that were in place before Hurricane Katrina. As a result, the majority of the projected future development in South Louisiana will take place in the more traditional Louisiana growth industries such as oil and gas and tourism. Calthorpe Associates provided this scenario using the “business-as-usual” projections prepared by Economy.com for each MSA and for each parish located outside of an MSA for the period 2010 through 2030. New Orleans District personnel extended these projections to the year 2050 based on the average annual “business-as-usual” growth rate between 2010 and 2034 as developed by Economy.com.

A third future development scenario, which was developed by New Orleans District personnel, used the “high employment” projections prepared by Economy.com for each MSA and for each coastal parish located outside of an MSA for the period 2010 through 2034. These projections were then extended to the year 2050 based on the “high employment” growth rate projected by Economy.com to occur between the years 2010 and 2034. Since the population growth rate for the five-year period following Hurricanes Katrina and Rita was not considered in the extension of the Economy.com projections, the growth rate used during the period 2034 to 2050 is relatively lower than the growth rate used by Calthorpe Associates for the period 2030 to 2050 in their “high employment” projections.

Future Land Use Allocation Scenarios

Calthorpe Associates also developed three land use allocation scenarios (compact, dispersed, and hybrid) for the “high employment” future development projections for the year 2050 to show the location and type of development expected to take place throughout southern Louisiana. New Orleans District personnel then applied the three land use allocation scenarios to the “business as usual” and to the “modified high employment”” future development scenarios. The specific location of the future development was primarily based on the existing and projected transportation systems in each area. However, other factors, including current and projected commercial activity, land elevation, susceptibility to flooding and other hazards, and environmental constraints such as wetlands, were also considered. The projected location and types of residential dwelling units varied under each of the three land use allocation scenarios.

Under the compact land use allocation scenario, residential development was primarily projected to occur in the census blocks located near the five major cities in the planning area, New Orleans, Baton Rouge, Houma, Lafayette, and Lake Charles. A larger proportion of multi-family dwelling units relative to the single-family residential construction was projected under this scenario. Under the dispersed land use allocation scenario, residential development was projected to spread out from the major cities, and there was more single-family residential construction relative to multi-family dwellings. The hybrid land use allocation is a combination of the compact and the dispersed land use allocations.

The projections by Calthorpe Associates included the number and classification of the residential and the non-residential properties for each of the three land use allocations projected by census block throughout the LACPR planning area for the year 2050. For example, it was projected that 32 percent of the total residential dwelling units would be single-family units under the compact land use allocation scenario, while 70 percent and 55 percent would be single-family units under the dispersed and the hybrid land use allocation scenarios, respectively.

Allocation of Future Development at the Parish Level

Thus far, the projections under the three future development scenarios and under the three land use allocation scenarios were made for the MSAs as a whole rather than for the individual parishes (with the exception of the more rural coastal parishes located outside of the five MSAs). In order to more accurately reflect the shifts in population that occurred as a result of Hurricanes Katrina and Rita, a method of allocating the growth to the individual parishes rather than the MSAs was developed by New Orleans District personnel. It was assumed that each parish would receive a percentage share of the population growth based on its share of the population within the MSA as projected for each of the three land use allocation scenarios with the “high employment” future development scenario for the year 2050. As an example, the population for Orleans Parish was projected to be 30 percent of the New Orleans MSA for the compact land use category, 25 percent for the disperse land use category, and 27 percent for the hybrid land use category. Thus, Orleans Parish was assumed to receive these percentages of the population growth in each of the other time periods between 2006 and 2050 depending on which land use category was selected. This same method was also used to develop the projections of total households and total employment under each of the different scenarios.

Projected Structure Inventory

The projections of population, number of households, and non-agricultural employment between 2nd quarter 2005 and the year 2050 were used to develop the residential and non-residential stage-damage relationships for each census block in the planning area for the three future development and three land-use scenarios. Calthorpe Associates provided the incremental residential and non-residential development by census block expected to occur during the period under the “high employment” future development scenario and under each of the three land use scenarios for South Louisiana. This projected incremental level of residential and non-residential development was added to the pre-Katrina (2nd quarter 2005) residential and non-residential development.

For residential property, the projected number of single-family, townhouses, multi-family, and mobile home dwelling units and the average square footage for each type of dwelling for the year 2050 were provided by Calthorpe for each census block. The Marshall and Swift Residential Valuation Service was then used to develop an average replacement cost per square footage across the five three-digit zip code areas in the LACPR planning area. The average replacement cost per square footage was multiplied by the average square footage to derive the total construction cost for each type of residential dwelling unit.

For non-residential properties, Calthorpe provided the projected number of office, retail, and industrial buildings and the total square footage for each type of non-residential building for each census block for the year 2050. The Marshall and Swift Commercial Valuation Service was then used to develop an average cost per square footage for each type of non-residential building across five zip code areas in the LACPR planning area. The average cost per square footage was multiplied by the average square footage to derive the total construction cost for each type of non-residential dwelling unit. The total replacement cost or exposure value for each type of non-residential buildings was totaled by census block and used to calculate the potential flood damages for the year 2050 under each of the three land use allocation scenarios.

In order to calculate the potential flood damages for the non-residential properties, each non-residential building was assigned a damage category (commercial or industrial), a structure type (metal frame, steel frame, or masonry bearing walls), and a content type (professional, retail, and warehouse) depth damage category, similar to the existing condition inventory in the GIS application. LIDAR data were used to assign the mean ground elevation to each census block with projected non-residential development. The building characteristics, one or two stories, slab or pier foundation, and the corresponding average height above ground, were all assigned based on information collected from the emergency managers of each parish in the LACPR planning area.

Stage-Damage Relationships for the year 2050 Under the High Employment Future Development Scenario

The projected incremental structure inventory and valuation data for the "high employment" future development scenario under each of the three land use allocation scenarios was combined in the GIS application with the projected elevation data and the depth-damage relationships to generate a stage-damage relationship for each census block that contained incremental residential or non-residential development for the year 2050. Flood damages were calculated at one-foot increments from the beginning damage elevation to an elevation where damages for all the structural categories have reached a maximum. In order to insure that this maximum had been reached, the maximum height of a slab foundation or of a pier foundation in each census block was added to the maximum depth of flooding (15 feet) included in the depth-damage relationships. Eight structural damage categories were considered: single-family residential, multi-family residential, manufactured housing/mobile homes, commercial, industrial, public, agricultural, and vehicles using 2006 price levels.

The future development stage-damage relationships were adjusted to reflect FEMA elevation requirements for new construction. Any residential and non-residential development projected to take place after the year 2010, including the rebuilding of structures damaged by Hurricanes Katrina and Rita, will have a first floor elevation equal to or greater than the stage associated with the 100-year frequency event.

Stage-Damage Relationships for the Years between 2nd Quarter 2005 and 2050 and for the Year 2075 Under the High Employment Future Development Scenario

Stage-damage relationships for each census block in the LACPR planning area were developed for 2nd quarter 2005 and for the year 2050 for the "high employment" future development scenario under each of the three land use allocation scenarios. The projected number of households in the coastal parishes was used to adjust the residential stage-damage relationships at the census block level for each year between 2nd quarter 2005 and the year 2050, while the projected non-agricultural employment level in the coastal parishes was used to adjust the non-residential stage-damage relationships at the census block level for a each year during the period.

The number of households under the "high employment" future development scenario and under each of the three land use allocation scenarios for each parish in the planning area projected for each of the years between the 2nd quarter 2005 and the year 2050 was expressed as a percentage of the total number of households projected for the year 2050. These percentages at the parish level were then used as the basis for projecting the residential stage-damage relationships at the census block level for each of the years during the period. For example, using the "high employment" future development scenario and the hybrid land use allocation scenario, it was determined that the number of households projected for Ascension Parish for the year 2040 was approximately 85 percent of the total number of households projected for Ascension Parish for the year 2050. Thus, the projected residential stage-damage relationship for each of the census blocks in Ascension Parish for the year 2040 would be 85 percent of the stage-damage relationship projected for that census block for the year 2050.

The level of non-agricultural employment under the "high employment" future development scenario under each of the three land use allocation scenarios for each parish in the planning area projected for each of the years between the 2nd quarter 2005 and the year 2050 was expressed as a percentage of the non-agricultural employment level projected for the year 2050. These percentages at the parish level were then used as the basis for projecting the non-residential stage-damage relationships at the census block level for each of the years during the period.

Stage-Damage Relationships Under the Business-As-Usual and Modified Full Employment Future Development Scenarios

A similar process was used to develop residential stage-damage relationships under the "business as usual" and the "modified high employment" future development scenarios with each of the three land use allocation scenarios for the year 2050 and for each of the years between 2nd quarter 2005 and the year 2050. However, since the breakdown by census blocks was not available for either of these future development scenarios, an additional adjustment was made to the residential stage-damage relationships developed for the "high employment" scenario in the year 2050. The total number of households projected for each parish under the "business as usual" and "modified high employment"" future development scenarios in the year 2050 were expressed as percentages of the total number of households projected for the parish in the year 2050 under the "high employment" scenario. These percentages were then used to develop residential stage-damage relationships for each of the census blocks in the planning area under the "business as usual" and "modified high employment"" scenarios for the year 2050.

This process was also used to adjust the non-residential stage-damage relationships projected for the year 2050 under the "business as usual" and "modified high employment"" future development scenarios with each of the three land use allocation scenarios to reflect the stage-damage relationships for each of the years between 2nd quarter 2005 and the year 2050. Again, since the breakdown of non-residential development by census blocks was not available under either of these future development scenarios, an additional adjustment was made to the non-residential stage-damage relationships developed under the "high employment" scenario for the year 2050. The level of non-agricultural employment projected for each parish under the "business as usual" and "modified high employment"" future development scenarios in the year 2050 were expressed as percentages of the total non-agricultural employment level projected for the parish in the year 2050 under the "high employment" scenario with each of the three land use allocation scenarios. These percentages were then used to develop non-residential stage-damage relationships for each of the census blocks in the planning area under the "business as usual" and "modified high employment"" scenarios for the year 2050.

Extension of the Projections to the Year 2075

Since the length of the project implementation period is uncertain, the projections of population, number of households, and employment under each of the three future development scenarios and under each of the three land use scenarios scenario were extended by New Orleans District to the year 2075. The average annual growth rate projected to occur between 2010 and 2034 was used to extend each set of projections from the year 2050 to the year 2075. The projected number of households for the year 2075 was used to estimate the residential damages, while the projected employment for the year 2075 was used to estimate the non-residential damages. These projected damages were used to develop stage-damage relationships under each of the future development and land use allocation scenarios for the year 2075.

EMERGENCY AND OTHER POST-FLOOD COST CATEGORIES

A flooded community typically incurs a variety of flood-related costs not associated with structural damages. The emergency costs associated with inundated residential properties include evacuation and subsistence, clean up and reoccupation costs, debris removal, and landscaping. The emergency costs associated with inundated non-residential properties include clean up and restoration costs, recovery of business records, and landscaping. These costs are incurred either by the Federal government, the occupants of inundated residential properties, or the owners of inundated non-residential properties. The depth-damage relationships developed for each of these emergency cost categories were used to develop emergency cost stage-damage relationships for the inundated residential and non-residential properties in the planning area.

The costs required for repair of inundated highways, streets, and railroad tracks were also considered in the analysis. The depth-damage relationships developed for highway, street, and railroad track repairs were used to develop stage-damage relationships for each of these categories.

Evacuation and Subsistence Costs

The experiences of residents affected by previous flood events, including Hurricanes Katrina and Rita, were used to estimate the evacuation and subsistence costs incurred by property owners and the Federal government immediately following a storm event. Residents of structures inundated between one and three feet above first floor elevation were evacuated from their homes for approximately three months following the flood event. During this period, most of the residents of evacuated households lived in hotels in cities north and west of the planning area. Based on the fiscal year 2007 government per diem for lodging in Dallas, Houston, Shreveport, Monroe, Little Rock, and Memphis, the average hotel rate is $75.33 per day, or $6,780 for the 3-month evacuation period. It should be noted that the lodging component of the government per diem is usually less than the non-contracted rates typical of hotels and motor lodges.

The average daily subsistence cost per evacuated household was also based on the average government per diem in the cities north and west of the planning area. The fiscal year 2007 average cost for meals prepared outside of the home was $47.67 per person, per day. Since the average household in the planning area as reported by the U.S. Census in the year 2000 contains 2.6 people, each evacuated household spent an average of $123.94 per day for meals. According to the U.S. Department of Agriculture, each household would have spent $8.32 per person, or $21.63 per household, on meals prepared in the home. Thus, the net additional food expenditure per household totaled approximately $102.31. The total evacuation and subsistence cost for the 90-day evacuation period was approximately $16,000 per inundated household.

For depths of flooding ranging between three and six feet above first floor elevation, the evacuation period increased to approximately one year. Most of these residents moved to an apartment closer to their inundated structure or to a FEMA trailer in front of their home after the initial three months of the evacuation period. Based on the national fair market rental assistance by FEMA following Hurricane Katrina, the average cost of renting an apartment was $800 per month, or $7,200 for the nine-months following the initial three-month evacuation period. According to an article in the Times Picayune, the average cost of a FEMA trailer, including the purchase price of $13,000, the cost of delivery, installation, maintenance, cleaning, and disposal, is approximately $60,000 per trailer for an 18-month "life cycle." Since the cost of a FEMA trailer is significantly greater than the cost of an apartment, the lower cost temporary housing alternative was used in this analysis. The average total evacuation and subsistence cost for the one-year period was approximately $23,200 per household. For depths of flooding greater than six feet, the period of evacuation was increased to eighteen months, and the total evacuation and subsistence cost increased to approximately $28,000 per household.

A depth-damage relationship for evacuation and subsistence costs was developed for each increment of flooding up to 15 feet above first floor elevation. These depth-damage relationships were then combined in the GIS application with the number of residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for evacuation and subsistence costs.

Residential Clean Up and Reoccupation Costs

The experiences of residents affected by previous flood events, including Hurricanes Katrina and Rita, were used to estimate the residential clean up and reoccupation costs incurred by residential households immediately following a storm event. Included in this category are the costs of driving to and meeting with insurance adjustors and contractors, the costs of interior clean up and dehumidifying the property, and the opportunity cost for the time spent by the resident meeting with the adjustors and contractors and inspecting the repairs. While the rebuilding process will likely last longer than one year, the clean up and reoccupation costs are based only on the actual hours estimated to be spent by residents on these activities.

Since the residents of properties inundated at least one foot above first floor elevation are evacuated for at least three months, they will periodically visit their properties during the evacuation period to inspect the extent of their damages, meet with insurance adjustors, and meet with contractors to determine the necessary repairs. Based on the experiences of residents evacuated from Hurricane Katrina, travel costs were estimated for a minimum of three visits during the evacuation period.

The average distance that the residents of each inundated household traveled to an evacuation destination was 350 miles, or 700 miles round trip. According to the Internal Revenue Service (IRS), the operation and maintenance cost, including gasoline, for each vehicle used in the evacuation process was $0.485 per mile. With a round trip cost of $339.50 per visit, the total transportation cost for three round trips to the inundated property during the period of evacuation was $1,019. This amount was applied to all residential structures that were inundated one foot or more above first floor elevation.

The estimated costs incurred by residents to clean up and gut their inundated properties were based on interviews with contractors and repair personnel in the planning area. The tasks involved in this cost category include obtaining permits, employing dehumidifiers, gutting the interior of the structure, sanitizing the salvageable items, and removing mold. A total of $13,500 was applied to each residential structure inundated at least one foot above first floor elevation. For mobile homes inundated at least one foot above first floor elevation, the clean up and gutting costs totaled $5,000.

During their period of evacuation, homeowners will devote many hours applying for governmental assistance, filing insurance claims, scheduling appointments, meeting with insurance adjustors and contractors, and supervising repair work. The opportunity cost associated with the time spent completing these tasks can be measured by the average hourly wage for residents in the planning area. According to a pre-Katrina homeowner survey completed by the Amite River Citizens Community Group following a non-hurricane related flood event in East Baton Rouge Parish, residents of structures inundated less than three feet above first floor elevation spent an average of 100 hours completing these tasks. The average nonagricultural wage rate in the planning area for 3rd quarter 2006, as derived from data reported by the Louisiana Department of Labor, was $18.08 per hour. Thus, the total opportunity cost for each resident whose property was inundated between one and three feet above the first floor elevation was determined to be $1,808.

For residential structures inundated three feet or more above first floor elevation, the experiences of residents flooded by Hurricane Katrina were considered. Several of these homeowners had accurately recorded the amount of time that they had spent completing various reoccupation tasks in the months following the storm. Based on these records, an average of approximately 571 hours is required to complete the following tasks: the initial clean up of the lot and exterior of house, meetings with insurance adjustors, telephone conversations with non-profit groups and government agencies, meetings with contractors, the overseeing of repair work, and the purchasing of replacement items. With an average wage of $18.08 per hour, the total opportunity cost for each homeowner whose property was inundated more than three feet above first floor elevation was $10,308.

A depth-damage relationship for clean up and reoccupation costs was developed for each increment of flooding up to 15 feet above first floor elevation. These depth-damage relationships were then combined in the GIS application with the number of residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for evacuation and subsistence costs.

Landscaping

After the completion of the residential clean up and reoccupation process, the costs associated with restoring the exterior of the property were considered. The average lot size of the residential properties in the planning area is 5,000 square feet, with approximately one half of this amount, or 2,500 square feet, devoted to landscaping. If the residential property is inundated with saltwater at a depth of 2 feet or more above first floor elevation, the grass, shrubs, and an average of one tree per property would need to be replaced. Data regarding the landscaping replacement were obtained from a local landscaping company, from Value Engineering, and from the landscape architects of the USACE. Damage to the fencing surrounding the property was not considered in this analysis because of the difficulty in separating the portion of the damage caused by water from the portion of the damage caused by wind.

Before new grass, plants, and trees can be planted on the property, the soil damaged by the saltwater must be removed, disposed of, and replaced. The cost to replace 6 inches of topsoil throughout the property, or approximately 46 cubic yards at $50 per cubic yard plus administrative costs, is $3,000. Approximately 7 grass palettes, each costing $300 plus labor and administrative costs, would be required to re-sod the property; the total cost of this task is $4,000. According to the landscape architects of the USACE, it would cost $3,500 to replace the shrubs (azaleas, rose bushes, camellias, gardenias, etc.) on the property, $4,000 to remove one damaged tree, and $100 to plant a new tree. The cost of labor is included in each of these costs. Thus, the total landscaping cost for each residential property is $14,600.

The total landscaping cost was applied to all residential structures that incurred flooding of 2 feet or greater above first floor elevation. This cost was used in the GIS application together with the number of residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for landscaping costs.

Debris Removal

The costs associated with the removal of debris from the curbside in front of inundated structures and the transporting of this debris to waste disposal sites were primarily incurred by the Federal government. According to emergency management officials from New Orleans District, each inundated residential structure created approximately 30 cubic yards of debris. The cost to remove this debris ranged from $15 to $25 per cubic yard with an average of $20 per cubic yard. Thus, the average cost of debris removal was $600 per inundated residential structure. This amount was applied to all residential structures that incurred flooding at least one-foot above the first floor elevation, and was used in the GIS application together with the number of residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for debris removal.

Total Residential Emergency Costs

A depth-damage relationship for the total of all residential emergency cost categories was developed for each increment of flooding up to 15 feet above first floor elevation. These depth-damage relationships were then combined in the GIS application with the number of residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for the total of all residential emergency cost categories.

Non-Residential Clean Up and Restoration Costs

Post-flood surveys of business owners and managers were conducted as part of the IWR Flood Damage Collection Program. These surveys consisted of personal interviews with the owners and managers of businesses in the New Orleans Metropolitan Area that experienced flooding due to Hurricane Katrina. Based on the responses to the survey of 161 businesses, the average cost of commercial clean up and business restoration was $134,947. Most of the non-residential structures included in the survey incurred flooding between two and eight feet above first floor elevation. Clean up and restoration costs include the cost of labor and materials to clean the interior and exterior of the building and to remove and dispose of debris. The average cost of salvaging and replacing business records was $4,946. The costs associated with restoring the exterior of the property, including landscaping, averaged $7,039. Thus, the clean up and restoration cost for each non-residential property that incurred flooding one or more feet above first-floor elevation totaled $146,932.

A depth-damage relationship for the total of all non-residential emergency cost categories was developed for each increment of flooding up to 15 feet above first floor elevation. These depth-damage relationships were then combined in the GIS application with the number of non-residential structures inundated at each one-foot increment of flooding to develop a stage-damage relationship for the total of all non-residential emergency cost categories.

Repairing of Highways, Streets, and Railroad Tracks

According to a report by the Louisiana Department of Transportation and Development, the total cost of repairing the road systems in Louisiana following Hurricanes Katrina and Rita was estimated to be $1.46 billion. Approximately $1.1 billion was needed to repair Federal roadways, and $359 million was needed to repair non-Federal roadways. While some of the major highways, streets, and railroad tracks throughout the area, which were inundated with floodwater for an extended period of time, experienced only minimal damages, other roadways and railways experienced major damages to both their surfaces and their foundations.

Based on data obtained from Engineering Division, the cost to repair each lane of an asphalt-paved highway is $200,000 per mile. Since a highway was defined in the analysis as containing four lanes, the total repair cost applied to each highway mile was

$800,000. The cost to repair each lane of a street was $100,000 per mile. Since local streets contain two lanes, the total repair cost applied to each mile was $200,000. Based on data obtained from Engineering Division, railroad track repairs cost $100 per linear foot, or $528,000 per mile. Revised depth-damage relationships for highways, streets, and railroad tracks were developed for each one-foot increment up to 15 feet of flooding by using these data to update the data developed as part of the Economic Data Survey for the Mississippi River and Tributaries Protected Area conducted by a contractor.

The GIS database, which contains the total number of miles of major and secondary highways, roads and streets, and railroad tracks in each census block, was combined with LIDAR DEM data, which provides the mean ground elevation for each census block, to assign a mean ground elevation to the roadways and railways in the planning area. Based on a sampling of LIDAR DEM data, the railroad tracks in the planning area were located an average of approximately 3 feet above the mean ground elevation of the census block.

The mean ground elevation in each census block was combined with the depth-damage relationship for highways and streets to develop stage-damage relationship for the highways and streets in that census block. The mean ground elevation plus the average height above ground for the railroad tracks in each census block was combined with the depth-damage relationship for railways to develop a stage-damage relationship for the railroad tracks in that census block. These relationships show the total number of highway, street, or railway miles inundated and the subsequent damage in each census block at each one-foot increment of flooding.

The GIS application was then used to determine the number of miles of highways, streets, and railroad tracks for the stages associated with each of the frequency storm events. Because fewer miles will flood with the project in place, the portion of the expected annual highway, street, and railroad track repair costs that will be reduced by the project alternatives is considered the highway, street, and railroad track repair costs saved.

AGRICULTURAL RESOURCES

National Economic Development (NED) agricultural benefits are defined as the value of increases in the agricultural output of the area and the cost savings in maintaining a given level of output. The benefits include reductions in production costs and in associated costs, the reduction in damage costs from floods, erosion, sedimentation, inadequate drainage, or inadequate water supply, the value of increased production of crops, and the economic efficiency of increasing the production of crops in the planning area area.

The National Agricultural Statistics Service (NASS) GIS database for the year 2005 was used to provide the location of each of the various crops farmed in the LACPR planning area. These crops include corn, cotton, rice, sorghum, soybeans, winter wheat, small grains (alfalfa, oats, millet, and rye) and hay, sugar cane, fallow cropland, pecans, and pasture. The number of citrus acres in Plaquemines Parish was provided by the Louisiana State University Agricultural Center (LSU AgCenter) and their location was estimated based on the location of fallow cropland in the area. The LSU AgCenter provided the number of acres of crawfish farming for each parish, and it was assumed that these acres were located in the same area as the rice acres. The GIS layer containing the location of each crop in the planning area was combined with the LIDAR DEM in the GIS application to determine the number of cleared agricultural acres inundated for each one-foot increase in stage. The acres of agricultural land were assigned to census blocks in the GIS Application in order to combine the damages to crops for each one-foot increase in stage with the increase in damage to residential and non-residential property, if any, within that census block. The number of acres that could be inundated for each one-foot increase in stage is commonly referred to as a stage-area curve.

Crop Damage Rate

The crop damage rate per acre inundated is defined as the difference between the net return per cleared acre in a year in which a storm event occurs and the net return per cleared acre in a year in which a storm event does not occur. The damage rates per inundated acre of all crops except pecans and citrus were developed based on farm budget analysis. Production cost and return data published by the LSU AgCenter and discussions with professors associated with the LSU AgCenter were used as inputs for each crops farm budget analysis. The crop damage rate per inundated acre of sugar cane was based on the damage rate developed as part of the Morganza to the Gulf, Louisiana Feasibility Study. The actual crop losses that resulted from saltwater inundation caused by Hurricanes Katrina and Rita were used to develop the damage rate per acre of small grains and hay, pecan and citrus crops.

In order to determine the flood damages to the corn, cotton, rice, sorghum, soybean, sugarcane and winter wheat crops and to crawfish farming, the monthly probability of a hurricane affecting the Louisiana coast, the production cycle of each crop, and the production costs and revenues per crop acre were considered. Data obtained from the National Oceanic and Atmospheric Administration (NOAA) for the period 1851 through 2005 were used to determine the probability of a storm affecting the Louisiana coast during each of the six months (June through November) in the hurricane season. The average yield for the period 2001 through 2005 (pre-Katrina/Rita) and the 2006 current normalized price (CNP) per crop were used to determine the gross annual revenue per crop. The average price received by crawfish farmers for the period 2001 through 2005 was applied to crawfish, since a CNP was not available for crawfish.

The production budgets obtained for each crop from the LSU AgCenter were used to determine the cumulative production costs expended for each month in the production cycle of each crop, beginning with the planting of the crop and ending with harvesting. These cumulative monthly expenditures were multiplied by the probability of a hurricane occurring during that month in order to calculate the expected value of the expended production costs. According to discussions with the professors associated with the LSU AgCenter, all revenues generated by crawfish farming will be lost if the ponds are inundated with saltwater. This same assumption was applied to corn, cotton, sorghum, and soybeans. Since winter wheat is harvested in May before the beginning of the hurricane season, it was assumed that there would be no loss to the crop. Also, it was assumed that there would be no crop loss to fallow land.

The damage rate per inundated crop acre is equal to the loss of the net income normally generated by the crop. It can be equivalently measured as gross revenues minus the expected value of the unexpended production costs for that year. For purposes of this analysis, it was assumed that total revenues would never be less than the cost of production for that crop (i.e. net returns are always greater than or equal to zero). This assumption was made because if net income is negative in a non-flood year, then the flood event would negate this loss and actually have a positive effect on the NED account.

The damage rate per inundated acre of pastureland was based on data obtained from the LSU AgCenter as part of a previous USACE study in Southwest Louisiana. According to this data, there are approximately 40,000 head of cattle grazing on 120,000 acres of pastureland in Vermilion Parish, with an average of three acres of pasture for each animal. The annual revenues generated by the pastureland averages about $16 million, or $133.33 per acre. In the event of a storm, the inundated acres from saltwater flooding would be completely unusable for one year. For small grains and hay, pecans and citrus crops, the total damage to these crops caused by Hurricanes Katrina and Rita as reported by the LSU AgCenter was divided by the number of inundated acres to derive a damage rate per crop acre flooded.

Non-Crop Damage Rate

In addition to the crop and pasture losses, there are other non-crop damages and expenses that would be incurred as the result of a storm event. These include losses to agricultural infrastructure (farm roads, fences, farm equipment, supplies, and drainage improvements) and agricultural land restoration costs. A weighted average of the non-crop flood damage rate per inundated acre was developed in June 2006 for Vicksburg District by Mississippi State University based on data obtained from eleven counties in Mississippi. This non-crop damage rate, which was calculated to be $77.59 per inundated acre, was applied to each acre of agricultural land inundated in the LACPR planning area. A non-crop damage rate of $491 for crawfish farms was developed using the damages to crawfish infrastructure from Hurricanes Katrina and Rita and the number of acres impacted.

Total Damage Rate

The total damage rate developed for each crop, including both crop loss and non-crop loss, was multiplied by the number of cleared acres inundated in order to calculate the total loss from inundation for each crop. The reduction in the acres inundated under the with-project alternatives was compared to the without-project condition and multiplied by the damage rates in order to determine the damages and benefits associated with each project alternative.

EQUIVALENT ANNUAL DAMAGES

Aggregated Stage-Damage Relationships

The stage-damage relationships for residential and non-residential structures, contents, and vehicles were combined with the stage-damage relationships for emergency costs, road, highway, and railroad track repairs, and agricultural resources to develop one aggregated stage-damage relationship for each census block. The stage-damage relationships at the census block level were then combined to develop an aggregated stage-damage relationship for each planning subunit. The aggregated stage-damage relationships were developed under two future development and land use allocation scenarios: "high employment" future development with dispersed land use allocation and "business as usual" future development with compact land use allocation.

Stage-Damage Uncertainty

Uncertainty is inherent in both the hydrologic and economic data used to calculate stage-damage relationships. While any of the economic variables could contain measurement errors, the most significant source of economic uncertainty arises from the methods used to assign ground elevations to the residential and non-residential structure inventory and agricultural resources. A significant source of uncertainty inherent in the economic data used to calculate stage-damage relationships is the method used to assign the topographical data to the residential and non-residential structure inventory and agricultural resources. Based on the error surrounding the LIDAR data and the error arising from the use of a single mean value to represent the elevation for an entire census block, this uncertainty was estimated to be plus or minus 2.34 feet at the 90 percent level of confidence. As an example, when rounded to the nearest foot, the damages calculated at the three-foot stage could range from the damages calculated for the one-foot stage to the damages calculated for the five-foot stage.

Stage-Frequency Data

The H&H Branch provided stage-frequency data for each planning subunit under existing and future without-project and with-project conditions. Stages for five (5) frequency storms (10, 100, 400, 1,000, and 2,000 year events) were provided at three levels of confidence (10 percent, 50 percent, and 90 percent), which quantify the hydrologic uncertainty inherent in the model. As an example, at the 90 percent level of confidence, the stages associated with each of the five frequency events are higher relative to those at the other two levels of confidence, and there is only a 10 percent chance that the actual stages will exceed the values predicted by the H&H model. The stage-frequency data for the without and with-project conditions were provided for six future scenarios based on the condition of the Louisiana coastline and the rate of relative sea level rise expected to occur over time. The first three scenarios assume that the Louisiana coastline will continue to degrade with zero, low, and high rates of relative sea level rise, respectively. The second three scenarios assume that the Louisiana coastline will be sustained at its current (2010) condition with zero, low, and high rates of relative sea level rise, respectively.

Damage Calculations

The stage-frequency data were combined with the stage-damage relationships to develop frequency-damage relationships for each planning subunit. Frequency-damage relationships were estimated for the no action alternative (degraded coastline) and the coastal restoration only alternative (coastline sustained at the 2010 condition). Both the nonstructural and the structural alternatives include coastal restoration measures. Each alternative was analyzed with a sustained (2010) Louisiana coastline and with low and high relative sea level rise, respectively. The alternatives were also analyzed under the business-as-usual future development and compact land use allocation scenario and under the high employment future development and dispersed land use scenario. The frequency-damage relationships were calculated for three levels of confidence (10 percent, 50 percent, and 90 percent) to account for the hydrologic uncertainty inherent in the H&H model.

Frequency-damage relationships were developed for three nonstructural alternatives (including coastal restoration), which included the raising in place of all residential and non-residential structures in each planning unit to an elevation above the 100-year event, the 400-year event and the 1,000-year event, respectively. If a structure needed to be raised more than 13 feet, then a buyout option was used, and the damages associated with that structure were removed from the analysis. The reduction in damages resulting from the buyout of all structures located in the V-zone areas that are highly susceptible to flooding were also removed from the analysis.

Frequency-damage relationships were developed for ten structural alternatives (including coastal restoration) in PU1 and thirteen structural alternatives (including coastal restoration) in PU2. The structural alternatives were designed for the 100-year, 400-year, and the 1,000-year event. The comprehensive plans include these same relationships with the addition of the reduction in damages resulting from the complementary nonstructural measures for those areas not protected by the structural plans.

The GIS application was used to weight the damages corresponding to each magnitude of flooding by the percentage chance of exceedance. From these weighted damages, the application was used to determine the expected annual damages for the base year (2025) and the year 2075 for the no action alternative, the coastal restoration only alternative, the combination coastal restoration and either structural or nonstructural alternatives, and the comprehensive alternatives.

The damages projected for the base year (2025) in both PU1 and PU2 were used for the year 2010 due to the availability of data and the time constraints for the completion of the analysis. The increase in the population and the number of households between the years 2010 and 2025 was determined to be less than 10 percent. For PU3 and PU4, damages for the year 2010 were projected using the 2010 population and number of households. The expected annual damages for each year between 2010 and 2075 were computed using straight-line linear interpolation. The initial construction period for each of the structural alternatives was assumed to begin in the year 2010 and the implementation period of the structural alternatives ranged from six to sixteen years. Thus, each alternative was assumed to be operational through the year 2075.

For the structural alternatives, the no action (degraded coastline) damages were used for the years between 2010 and the year in which the project becomes operational, and the reduction in damages relative to the no action alternative were used for the remaining years through the year 2075. For the nonstructural alternatives, a 15-year implementation period was used. The reduction in damages relative to the no action alternative was assumed to occur at a uniform rate between the year 2010 and the year 2075.

Since the comprehensive plans included complementary nonstructural measures, the reduction in damages due to the nonstructural alternatives was estimated during the implementation period for each alternative. The damage reduction resulting from the structural alternatives along with the complementary nonstructural measures was estimated through the year 2075.

The fiscal year 2007 Federal discount rate of 4-7/8 percent was used to compound the stream of expected annual flood damages before the base year (2025) and to discount the stream of expected annual damages occurring after the base year in order to calculate the total present value of the damages in the year 2025. The present value of the expected annual damages was then amortized using the Federal discount rate to calculate the equivalent annual damages. These equivalent annual damages were calculated for three levels of confidence (10 percent, 50 percent, and 90 percent) to account for the hydrologic uncertainty inherent in the H&H model.

PRESENT VALUE COSTS

Cost estimates were developed for each of the coastal restoration only alternatives and for each alternative combining coastal restoration with either nonstructural or structural alternatives. Comprehensive cost estimates were provided for a combination of a coastal restoration with both nonstructural and structural alternatives. These costs were based on the design criteria for the 90 percent level of confidence.

The coastal restoration only alternatives for PU1 and PU2 were designed to sustain the Louisiana coastline at its condition in the year 2010. The coastal restoration measures include marsh creation, diversions, shore protection, reinforcement of natural ridges, and building up the barrier islands. Only the first three measures were considered for PU1, while all five measures were considered for PU2. Costs were initially developed for all five coastal restoration only alternatives (R1 through R5), but were then screened to only three alternatives (R1 through R3). When the coastal restoration alternatives were combined with a nonstructural alternative, a structural alternative, or both a nonstructural and a structural alternative for PU1 and PU2, only the costs for R2 were used.

Costs were developed for three nonstructural alternatives (including coastal restoration), which included the raising all of residential and non-residential structures in each planning unit to an elevation above the 100-year event, the 400-year event and the 1,000-year event, respectively. A buyout cost estimate was used for those structures that were required to be raised more than 13 feet above the ground. Nonstructural cost estimates were also provided for the buyout of all structures located in the V-zone areas that are highly susceptible to flooding.

Cost estimates were provided for ten structural alternatives (including coastal restoration) in PU1 and thirteen structural alternatives (including coastal restoration) in PU2. The structural alternatives were designed for the 100-year, 400-year, or 1,000 year event. The comprehensive plans include these same cost estimates with the addition of the costs of complementary nonstructural measures for those areas not protected by the structural plans.

Costs for each of the coastal restoration only plans, the combination coastal restoration and either structural or nonstructural plans, and the comprehensive plans were estimated under four future condition scenarios based on the condition of the Louisiana coastline and the relative sea level rise. The first two scenarios assume that the Louisiana coastline will be sustained at its current condition with no further degradation and with low and high relative sea level rise, respectively. The third and fourth scenarios assume that the coastline will continue to degrade with low and high rates of relative sea level rise, respectively.

The cost estimates for each alternative were provided using October 2006 price levels over the period beginning in the year 2010 and ending in the year 2075. For the structural alternatives, the estimates included initial construction costs, mitigation costs, the costs of levee lifts, and the required operation and maintenance (O&M) expenditures. Since the initial construction period of the various structural alternatives ranges from six to sixteen years, the O&M expenditures for each cost estimate were extended through the year 2075 to insure that each alternative was operational through the year 2075. The implementation period for the coastal restoration only alternatives and for the coastal restoration alternative with nonstructural alternatives was assumed to be 15 years. The present value of the life cycle costs for each alternative was calculated using the fiscal year 2007 Federal discount rate of 4-7/8 percent. The cost for each alternative was either compounded or discounted to reflect a common base year, the year 2025, using the Federal discount rate.

REGIONAL ECONOMIC DEVELOPMENT IMPACTS

The customized GIS application used to assess flood damages to residential and non-residential properties in the LACPR planning area was also be used to determine the direct regional impacts of a storm. These direct impacts were measured by changes in employment, wages, and output under without-project conditions and under the with-project conditions for each of the alternatives.

Methodology

The employment, wages, and output associated with each commercial property in a census block were adversely affected whenever the stage associated with a frequency storm event at the planning subunit level reaches or exceeds the first floor elevation of the structure. The impacts on employment were based on data provided by the Louisiana Department of Labor (LDOL) for 2nd quarter 2005 plus the incremental non-residential development projected by Calthorpe Associates to occur by the year 2050. These data were adjusted annually through the year 2034 using the population and employment projections provided by Economy.com, and they were extended through the year 2075 using data provided by Calthorpe Associates.

The increment of non-residential development projected for the year 2050 was separated into three non-residential categories: retail, office and mixed use, and industrial. A corresponding NAICS code (44, 54, and 32, respectively) was assigned to each non-residential category. The quarterly wages associated with the employees in each NAICS code for the 2nd quarter 2005 were annualized and then used to represent the impacted annual wages. The projected growth in output, or sales, for the businesses in each NAICS code was applied to the 2005 annual wages in order to adjust the growth in wages for each year. The annual wages were represented in 2006 prices.

The impact on output, or sales, of the commercial establishments in each census block in the planning area was based on the annual employment-to-output ratio developed by NAICS code for the 70-sector Regional Economic Model Incorporated (REMI) as part of the IPET Report. Output, or sales, per employee was linked to each two or three digit NAICS code assigned to businesses by LDOL to estimate the impact of flooding on annual output for the study year (2010), the base year (2025), and the year 2075. The annual employment-to-output ratio for the year 2050 was assumed to be constant through the year 2075.

Data were developed for five frequency events (10-year, 100-year, 400-year, 1,000-year, and 2,000-year) and were converted to average annual values and then to equivalent annual values. The employment, total wages, and output affected by each frequency storm event were then aggregated for each planning unit. These data are used to demonstrate the direct regional economic impacts for the without-project conditions and for the selected project alternatives on an equivalent annual basis.

Development of a System-wide Model

In general, regional economic policy analysis models use simulations to assess the economic effects of various policies relating to economic development, transportation, energy, the environment and taxation, on regional areas. Regional economies compete with one another within a national economy, and as such exhibit different behavior than national economies, such as the presence of second and third-round multiplier effects.

The development of a system-wide model to measure regional impacts will build upon these current estimates of direct regional effects. The advancement will be centered upon the calculation of changes in regional output, income, and employment that results from second-round and third-round spending effects, or lack thereof. The multiplier effects captured in this approach are embedded within a regional input-output model that was developed by Regional Economic Models, Inc. (REMI). It was this model that was used by the Interagency Performance Evaluation Team (IPET) to estimate the regional economic impacts associated with Hurricane Katrina in September 2005. The advantage of the REMI model over a number of alternative regional input-output models lies with its superior ability to trace reductions in output, income, and employment associated with disruptions to the established interrelationships among industrial sectors, whereas more conventional models are restricted to measuring increases in these variables as a result of a positive stimulus that is introduced into the system.

REMI Model

The REMI model uses a wide variety of economic indicators to describe the effects of policies on regional economies. It uses a large set of inputs from the following five (5) categories:

1) *Output and Demand*: Describes the output in each industry based on demand for that industry. Demand is generated by consumption, investment, government spending, and intermediate income. Subsequent determinants include real per capita disposable income, relative prices, the elasticity of demand with respect to income, and the size of the population. In addition to being influenced by demand in the home region, output is also influenced by demand in other regions, the region's market share, and the exports to other nations. The REMI model is the only input-output model to account for the displacement or augmentation effects that location choices have on other local firms.

2) *Labor and Capital Demand*: Describes the characteristics of labor including productivity, intensity, and optimal amounts of capital relative to the availability of labor.

3) *Demographic/Population and Labor Force*: Demographic information about the region, including birth and survival rates for each group. Based on the size and labor force participation rates for each group, the labor supply can be determined. This block also accounts for migration characteristics of the population.

4) *Wages, Prices, and Costs*: The interactions between the costs of labor, goods, and production will dictate how and how much they will be used – the cost of production for each industry is the cost of its inputs (labor, capital, and fuel). Access is another important characteristic because of the resulting transport and transaction costs.

5) *Market Shares*: The proportion of markets, both local and export, that each industry has captured.

REMI software allows for discrete, single-event modeling of a regional system that is defined according to the parameters of the study. Because model execution is relatively labor-intensive, it was found not to constitute a suitable tool for screening through a series of over one hundred alternatives. This level of effort is accentuated by the requirement that sufficient runs for a range of frequency events be conducted within each construction alternative such that an average annual equivalent value can be derived. Finally, unlike specific estimates of direct impacts such as the number of residences damages and affected population, multiplier-based regional impacts span across planning units since the industrial linkages are defined for integrated economic regions. Therefore, the possibility and desirability of defining economic regions within the REMI model to coincide with that of planning units requires further investigation once the number of final alternatives has been determined. This effort will be conducted as part of follow-up investigations to be conducted after the final array of project alternatives is established.

METRICS

In previous water resource studies, project alternatives were compared and selected based on the ratio of the National Economic Development (NED) equivalent annual benefits derived from the alternative to the average annual project costs. The alternative that generated the highest net benefits and maximized the ecosystem benefits was considered the NED/NER plan. However, for LACPR, a more comprehensive method was developed to compare the alternatives. This method encompasses a broader range of objectives and performance criteria to be used in the evaluation process. A system of quantifiable parameters, or metrics, was developed to evaluate and rank the alternatives based on the four planning objectives for LACPR: people, economy, environment, and culture. These metrics not only consider the criteria of the National Economic Development and National Ecosystem Restoration (NED/NER) account, as in previous studies, but also consider the criteria of the Regional Economic Development (RED), the Environmental Quality (EQ), and the Other Social Effects (OSE) accounts.

NED Metrics

Data from the economic analysis were used to evaluate each project alternative based on the criteria of the NED/NER, RED, and OSE accounts. The three metrics developed for the NED/NER account include equivalent annual damages, life cycle costs, and the length of time (in years) required to construct and implement each of the alternatives. Damages were calculated for the stages associated with five frequency events (10-year, 100-year, 400-year, 1,000-year, and 2,000 year) to derive the expected annual damages. The expected annual damages were converted to an equivalent annual value using the Federal discount rate. The equivalent annual damage value includes damages to residential and non-residential properties, emergency losses, losses to agricultural resources, and damages to the transportation infrastructure. An equivalent annual damage value was provided for both the degraded and maintained coast, for the high-employment future development and dispersed land use allocation scenarios, and for the business-as-usual future development and compact land use allocation scenarios, and for the 10, 50, and 90 percent confidence intervals surrounding the hydrologic data.

Life-cycle costs, which were prepared for each alternative, include initial implementation costs, operations, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs, real estate costs, and mitigation costs. Since these costs occur at various times during the life cycle of the alternatives, the costs were discounted to the base year (2025) to reflect their present value and were then expressed in October 2006 price levels. This process allows for the comparison of alternatives with different investment patterns. The construction and implementation time metric considers the number of years required to complete the construction of each alternative and for the alternative to begin providing flood risk reduction. An alternative with a shorter construction and implementation period could provide less flood risk reduction to a community than other alternatives, but it would provide flood risk reduction to the community sooner. Thus, there could be a tradeoff between the time that flood risk reduction begins and the overall magnitude of the risk reduction provided.

RED Metrics

Three metrics were developed to assess the direct impacts of a storm event on the regional economy based on the criteria of the RED account. These metrics include gross regional output, number of people employed, and average earned income. Indirect impacts, such as the reduced customer base following a storm event and the closing of related businesses, are not currently considered by the metrics for the RED account. However, these indirect impacts will be considered when the REMI model becomes available. The output, or sales, employment, and earned income associated with each commercial property in a census block under the no action condition and for each alternative are assumed to be affected whenever the stage associated with a frequency storm event at the planning subunit level reaches or exceeds the first floor elevation of the structure. Data were developed for five frequency events (10-year, 100-year, 400-year, 1,000-year, and 2,000 year) to derive the expected annual values. These expected annual values were converted to an equivalent annual value using the Federal discount rate.

OSE Metrics

A metric for residual population impacted was developed to assess the ability of alternatives to protect the health and safety of the public from a storm event based on the criteria of the OSE account. The impacted population is defined as the total number of residents in each census block in which the stage associated with a frequency storm event is greater than the mean ground elevation of that census block. The population metric does not consider the portion of the population that would evacuate before a storm event. Data were developed for five frequency events (10-year, 100-year, 400-year, 1,000-year, and 2,000 year) to derive the expected annual values. These expected annual values were converted to an equivalent annual value using the Federal discount rate.